Tape Recorder Theory and Maintenance

A Course Taught by Dale Manquen

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History of the Course

In the mid '70's I had the opportunity to help Jack Williams of Pacific Recorders and Engineering in San Diego with the checkout of several new MCI tape recorders that he was delivering to his customers. Jack's sales to the broadcast industry were growing rapidly and he needed to upgrade his technical staff to support this higher level of activity. He asked me to put together a comprehensive training program that would be suitable for his technicians and his customers' techs.

My approach was to concentrate on the underlying principles and fundamentals that form the common basis for all magnetic recorders. If the student knew what the recorder was supposed to do, then he could pinpoint the specific circuit and component that did each task on his brand and model of recorder. This approach was in sharp contrast to the tape machine manufacturers' courses that stressed how to fix only their machine with instructions such as "Adjust R26 1/4 turn "

The general coverage provides the tools to deal with any brand and type of magnetic tape recorder, including new models that are introduced in the future. My students have easily made the transition to digital recorders by applying the same fundamental concepts.

We learn how to unravel to complicated ball of interacting parts that form a tape recording system. We learn how to isolate problems due to heads, the tape transport, signal electronics circuits and even the tape stock.

The course emphasizes preventive maintenance. How can you spot the small changes that will become a major problem if not corrected quickly? The real value of a service technician is not in how fast he can fix something once it has broken. It is how seldom his equipment fails. Don't you want your auto mechanic to help you avoid car breakdowns rather than choosing the mechanic with the fastest tow truck?

My career has provided me with a diverse background that provides many first-hand anecdotes to illustrate the topics. I have designed tape recorders from the ground up - both mechanisms and electronics. I have worked in the Ampex Magnetic Tape Division. I have designed and built specialized test equipment for analyzing recorders. And, yes, I have worked in film scoring studios and on remote recording crews where breakdowns are incredibly expensive.

Each offering of the course is tailored to the group of students and their specific interests. The examples are chosen from the machines that the students must maintain. The original offerings were 40-hour courses, but I have since developed a shorter 32-hour version. Slides, overhead transparencies and real parts from recorders augment the lectures. We even re-lap a worn head in class.

Over the years, I have taught this course many times at venues that include L.A., San Diego, Dallas and New York City. My graduates include some of the chief engineers of major studios and some of the best freelance techs. And I still get an occasional call from a student who wants to talk over a specific problem that he has encountered. Would you care to join this rather exclusive group?

Outline of Course

A. Magnetic Recording Theory

1. Basic electromagnetics - Flux > Voltage
    a. Ring core heads
    b. Magnetic particles
2. Magnetic tape
    a. Manufacturing
    b. Performance characteristics
    c. Testing
3. Playback or reproduction
    a. Wavelength vs. frequency
    b. Output vs. frequency
    c. Spacing loss
    d. Gap length loss
    e. Azimuth loss
    f. Thickness loss
    g. Contour effect
    h. Fringing
    i. Crosstalk and guardbands
    j. Eddy currents
    k. Shielding
    l. Track configurations vs. signal-to-noise
    m. The flux loop
4. Recording Hysteresis curves
    a. High frequency bias
    b. Self demagnetization
    c. Distortion
    d. Erasure
        1) Bulk degaussers
        2) Double-gap erase heads
    e. Printthrough
    f. Linearizers
5. Magnetic head designs
    a. Ferrite vs. metal Construction
    b. Relapping

d. Undercutting

e. Adjustments

1) Azimuth vs. phasing

2) Zenith

3) Height

4) Racking

5) Wrap

6. Tape transports

a. Types of motors

1) Synchronous a. c.

2) Induction a.c.

3) Shunt d.c.

4) Series d.c.

6) Brushless d.c.

7) Pabst motor

8) Printed circuit motor

b. Constant velocity drives

1) Wow vs. flutter

2) Line frequency control

3)Servo

a) Tachometers

b) Velocity vs. phase lock

c. Constant tape tension drives

1) Capstan derived tensions

2) Fixed tension

3) Two point approximation

4) Open loop "calculated"

5) Direct sensing

d. Guides

1) Edge guides

2) Flanged guides

3) Rotary guides

e. Solenoids

1) Flat bottom linear

2) Taper bottom linear

3) Rotary

4) Torquers

f. Bearings

1) Ball Bearings

2) Bushings

g. Dashpots
h. Control logic

7. Digital tape transports

a. Wavelength and signal-to-noise tradeoffs for digital recording

b. Longitudinal multitrack digital recorders
c. Helical scan digital recorders
d. A/D and D/A considerations
e. Clocking, jitter, flutter and dropouts
f. Error detection and correction

B. Circuits

1. Understanding op amps
2. Power supplies
3. Motor drivers
4. Reproduce Circuits
   a. Equalization standards
   b. Noise problems
   c. Head resonance
   d. The flux loop
   e. Phase rotation networks
5. Record circuits
   a. Equalization
   b. Head driver
   c. Predistortion or linearizing
   d. Headroom
6. Bias/erase circuits
   a. Oscillators
   b. Push-pull transformer coupled
   c. Mixing and tuning
7. Signal and deck logic
   a. Basics of logic
      1) Truth tables
      2) Gates, latches, flip-flops, and counters
      3) Binary numbers
   b. Relays vs. FET's
   c. Motion/direction sense
   d. Power control

C. Specific examples from various manufacturers

D. Test instruments and calibration procedures

1. Test Equipment

a. Oscillator
b. Oscilloscope
c. Meter
d. Harmonic/IM distortion
e. Wave analyzer
f. Flutter meter
g. Equalized flux loop
h. Degausser
i. Monitor
j. Alignment tapes
k. Tape tension gauge
l. Magnetometer
m. Micrometer/Caliper/Dial Indicator

2. Alignment
    a. Transport
        1) Tension
        2) Speed
        3) Heads
    b. Reproduce level and equalization
    c. Bias
    d. Record level, equalization, & predistortion
    e. Erase

E. General troubleshooting tips

F. Bibliography

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LOW NOISE ELECTRONIC DESIGN by Motchenbacher, C.D. & Fitchen, F.C., John Wiley & Sons NY 1973

Videotapes

A Chronology of American Tape Recording produced by Dale Manquen for the Audio Engineering Society

An Afternoon with Jack Mullin, AES

Audiotapes

LA AES Section Grounding Workshop, AES